# Retrieving dust refractive index in the thermal infrared from AIRS and MODIS observations: information content analysis and case studies

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Mineral dust contributes over half of the total mass of atmospheric aerosols emitted from global continental sources, causing significant radiative impact in the infrared (IR) spectrum. Large uncertainty exists in the estimation of its IR radiative forcing due to limited knowledge of spectral refractive index. In this research, we quantify the information contained in observations as obtained from a paired combination of sounder and imager measurements, i.e., the Atmospheric Infrared Sounder (AIRS)'s hyperspectral IR radiance and Moderate resolution Imaging Spectroradiometer (MODIS) Aerosol Optical Depth (AOD). A variety of ancillary data are used to provide additional constrains towards a reliable retrieval, which include particle size distribution from the Aerosol Robotic Network (AERONET) and aerosol heights from the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP). In addition, the Principal Component Analysis (PCA) is applied to the spectra of dust refractive index, which can effectively reduce the spectral redundancy. We found that five principal components are sufficient to explain more than 97% variance of real or imaginary part of refractive index in IR.

We apply UNL-VRTM [1] (www.unl-vrtm.com) to simulate AIRS radiances and the Jacobians of AIRS radiances with respect to these PC's weighting coefficients which are in turn used for information content analysis. MODIS AOD is used as part of the observation vector, while AERONET particle size distribution and CALIOP aerosol height are used as model parameters for UNL-VRTM and their uncertainties are considered in the information content analysis. These simulations cover an entire AIRS's spectral range of 3.7 – 15.4 μm. We then identify an optimal subset of AIRS channels for constraining dust spectral refractive index through sequential forward selection technique [2]. These results are theoretical basis for using paired sounder-imager observations to constrain dust spectral refractive index. Some preliminary results of using real data for a dust case in the mid-east will also be shown.

## References

[1] Wang, J., X. Xu, S. Ding, J. Zeng, R. Spurr, X. Liu, K. Chance, and M. Mishchenko, 2014: A numerical testbed for remote sensing of aerosols, and its demonstration for evaluating retrieval synergy from a geostationary satellite constellation of GEO-CAPE and GOES-R. *J. Quant. Spectrosc. Radiat. Transf.* **146**, 510–528.

[2] Hou, W., J. Wang, X. Xu, and J. S. Reid, 2017: An algorithm for hyperspectral remote sensing of aerosols: 2. Information content analysis for aerosol parameters and principal components of surface spectra. *J. Quant. Spectrosc. Radiat. Transf.* **192**, 14–29.

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